A HOT-ELECTRON FAR-INFRARED DIRECT DETECTOR

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A new approach is proposed to improve the sensitivity of direct-detection bolometers at millimeter, submillimeter and far-infrared wavelengths. The idea is to adjust a speed of the thermal relaxation of hot-electrons in a nanometer size normal metal or superconductive transition edge bolometer by controlling the elastic electron mean free path. If the bolometer contacts are made of a superconductor with high critical temperature (Nb, Pb etc.) then the thermal diffusion into the contacts is absent because of the Andreev's reflection and the electron-phonon relaxation is the only mechanism for heat removal. The relaxation rate should behave as $T^4 l$ at subkelvin temperatures (l is the electron elastic mean free path) and can be reduced by factor of 10-100 by decreasing l. Then an antenna- or waveguide-coupled bolometer with a time constant $\sim 10^{-3}$ to 10^{-5} s at $T \approx 0.1$-0.3 K will exhibit photon-noise limited performance in millimeter and submillimeter range. The choice of the bolometer material is a tradeoff between a low electron heat capacity and fabrication.

A state-of-the-art bolometer currently offers NEP $\approx 10^{-17}$ W$\sqrt{\text{Hz}}$ at 100 mK along with a ≈ 2 msec time constant. The bolometer we propose will have a figure-of-merit, NEP$\sqrt{\tau}$, which is 10^3 times smaller. This will allow for a tremendous increase in speed which will have a significant impact for observational mapping applications. Alternatively, the bolometer could operate at higher temperature with still superior sensitivity. This device can significantly increase a science return and reduce the cost for future observational missions.

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